Strategic Approaches to Trading Science Objectives Against Measurements and Mission Design:

Mission Architecture and Concept Maturation at the Jet Propulsion Laboratory

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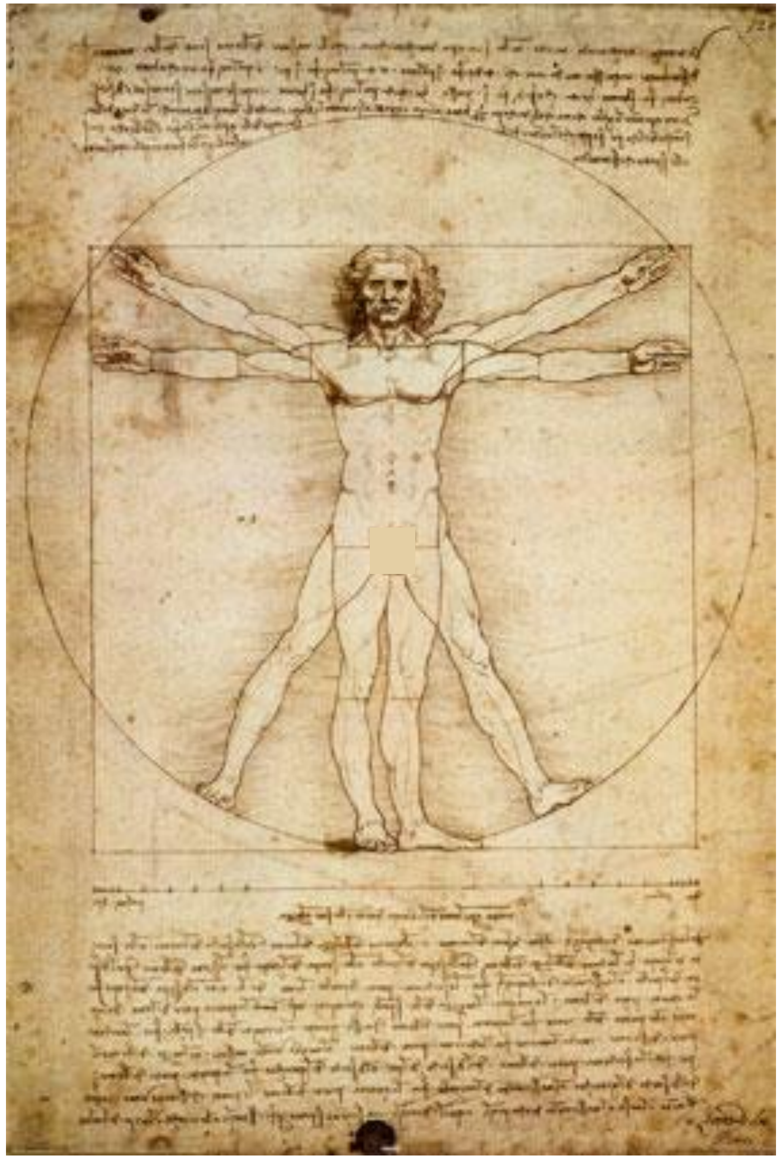
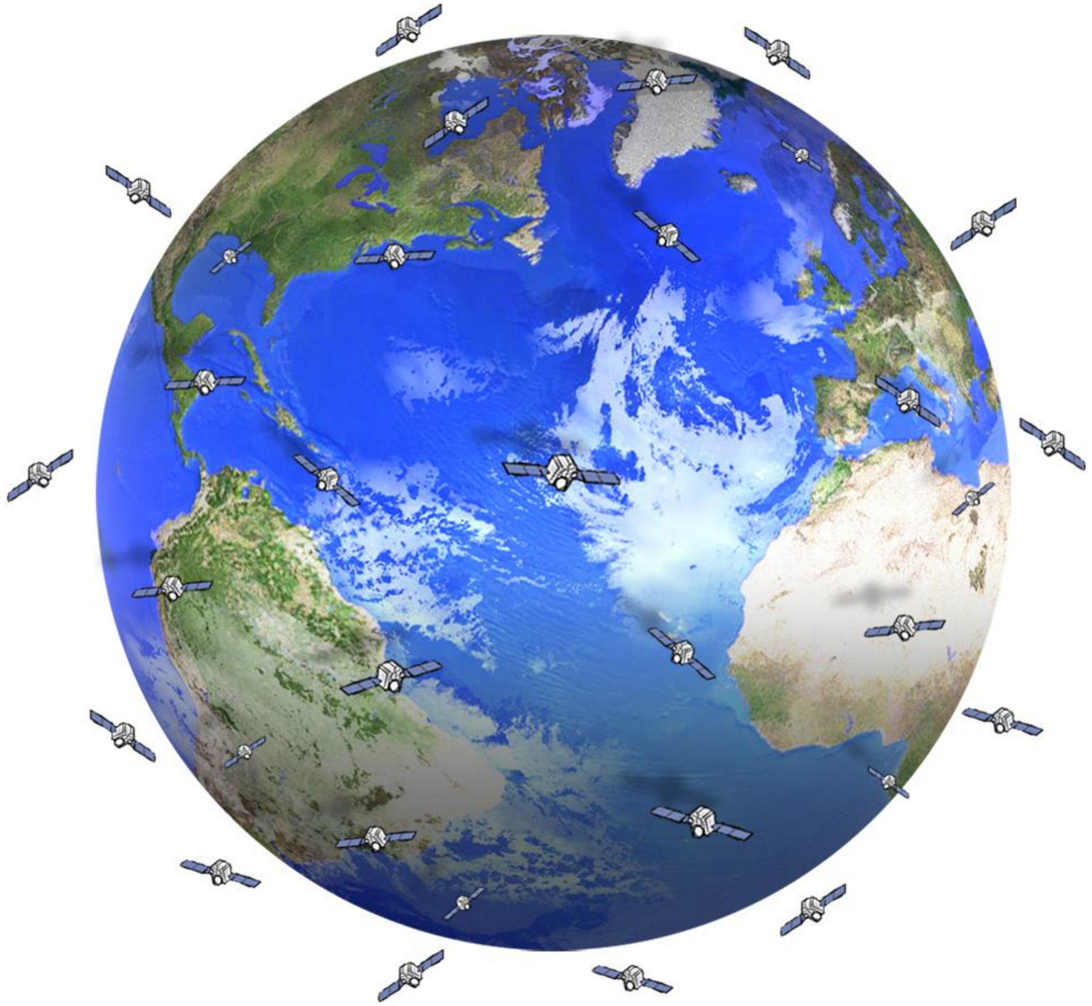


Missions that fly return *infinitely* more data than missions that don't



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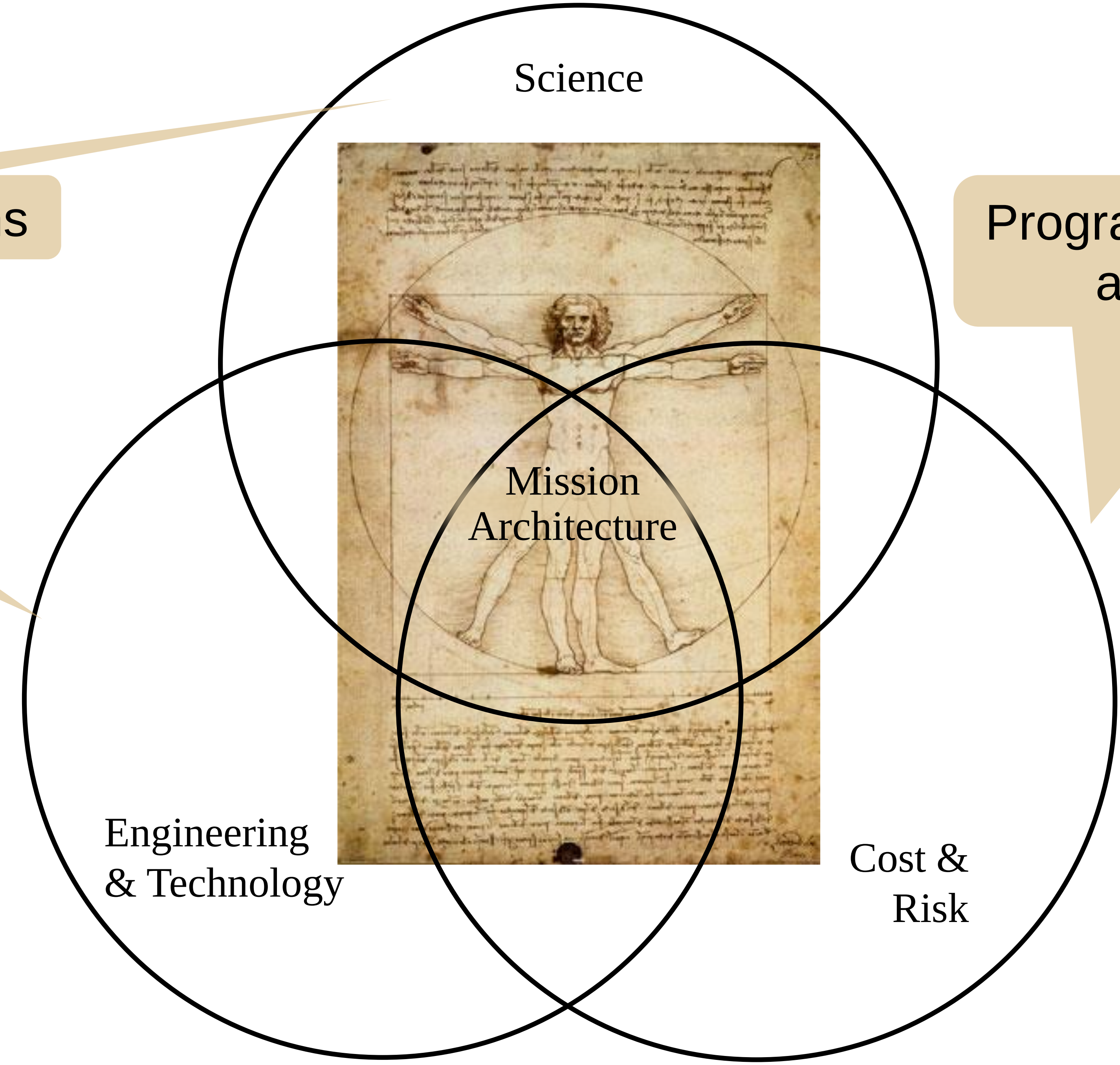
Missions happen when…

Compelling Questions

Feasible Solutions

Programmatically Acceptable and Credible Costs



What happened during the last Earth Science Decadal?

TABLE ES.2 Launch, Orbit, and Instrument Specifications for Missions Recommended to NASA

Decadal Survey Mission	Mission Description	Orbit[a]	Instruments	Rough Cost Estimate (FY 06 $million)
2010-2013				
CLARREO (NASA portion)	Solar and Earth radiation; spectrally resolved forcing and response of the climate system	LEO, Precessing	Absolute, spectrally resolved interferometer	200
SMAP	Soil moisture and freeze-thaw for weather and water cycle processes	LEO, SSO	L-band radar L-band radiometer	300
ICESat-II	Ice sheet height changes for climate change diagnosis	LEO, Non-SSO	Laser altimeter	300
DESDynI	Surface and ice sheet deformation for understanding natural hazards and climate; vegetation structure for ecosystem health	LEO, SSO	L-band InSAR Laser altimeter	700
2013-2016				
HyspIRI	Land surface composition for agriculture and mineral characterization; vegetation types for ecosystem health	LEO, SSO	Hyperspectral spectrometer	300
ASCENDS	Day/night, all-latitude, all-season CO_2 column integrals for climate emissions	LEO, SSO	Multifrequency laser	400
SWOT	Ocean, lake, and river water levels for ocean and inland water dynamics	LEO, SSO	Ka- or Ku-band radar Ku-band altimeter Microwave radiometer	450
GEO-CAPE	Atmospheric gas columns for air quality forecasts; ocean color for coastal ecosystem health and climate emissions	GEO	High-spatial-resolution hyperspectral spectrometer Low-spatial-resolution imaging spectrometer IR correlation radiometer	550
ACE	Aerosol and cloud profiles for climate and water cycle; ocean color for open ocean biogeochemistry	LEO, SSO	Backscatter lidar Multiangle polarimeter Doppler radar	800
2016-2020				
LIST	Land surface topography for landslide hazards and water runoff	LEO, SSO	Laser altimeter	300
PATH	High-frequency, all-weather temperature and humidity soundings for weather forecasting and sea-surface temperature[b]	GEO	Microwave array spectrometer	450
GRACE-II	High-temporal-resolution gravity fields for tracking large-scale water movement	LEO, SSO	Microwave or laser ranging system	450
SCLP	Snow accumulation for freshwater availability	LEO, SSO	Ku- and X-band radars K- and Ka-band radiometers	500
GACM	Ozone and related gases for intercontinental air quality and stratospheric ozone layer prediction	LEO, SSO	UV spectrometer IR spectrometer Microwave limb sounder	600
3D-Winds (Demo)	Tropospheric winds for weather forecasting and pollution transport	LEO, SSO	Doppler lidar	650

Priorities from the NRC, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*, The National Academies Press, Washington, D.C., 2007.

What missions are going forward?

- ✓ SMAP launched January 31, 2015
- ✓ ICESat-2 scheduled for launch in 2018
- ✓ NISAR scheduled for launch in 2020
- ✓ SWOT scheduled for launch in 2021
- ✓ GRACE-II scheduled for launch in 2018

- ✓ ACE and GEO-CAPE science objectives will be partially achieved by PACE and TEMPO missions
- ✓ ASCENDS and SCLP are being addressed through significant airborne measurement campaigns

Why do some missions proceed and others not?

Traditional Approach

Opportunity

↓

Science

↓

Engineering

↓

Cost

↓

Concurrent Approach

Opportunity

Science

Cost

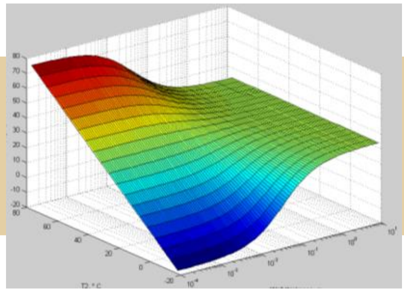
Engineering

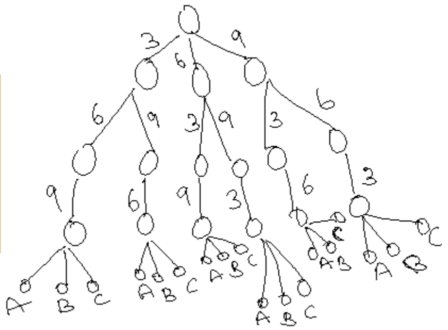
Innovation

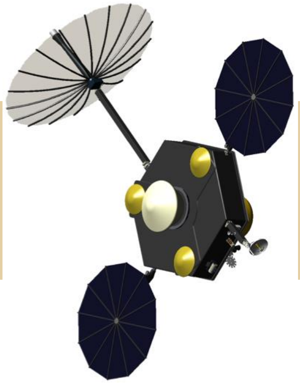
↓

$uccess

How do I get the Science I want?







Idea Generation
Organize and *rank* ideas based on *figures of merit*

Initial Feasibility
Quantitatively examine an idea for both *technical* and *programmatic* feasibility using analysis tools

Trade Space Exploration
Efficiently explore the *value*, *cost*, and *risk* trade space for mission concepts

Baseline Concept
Point Design at the component level with *validated, integrated* models

Science Solutions

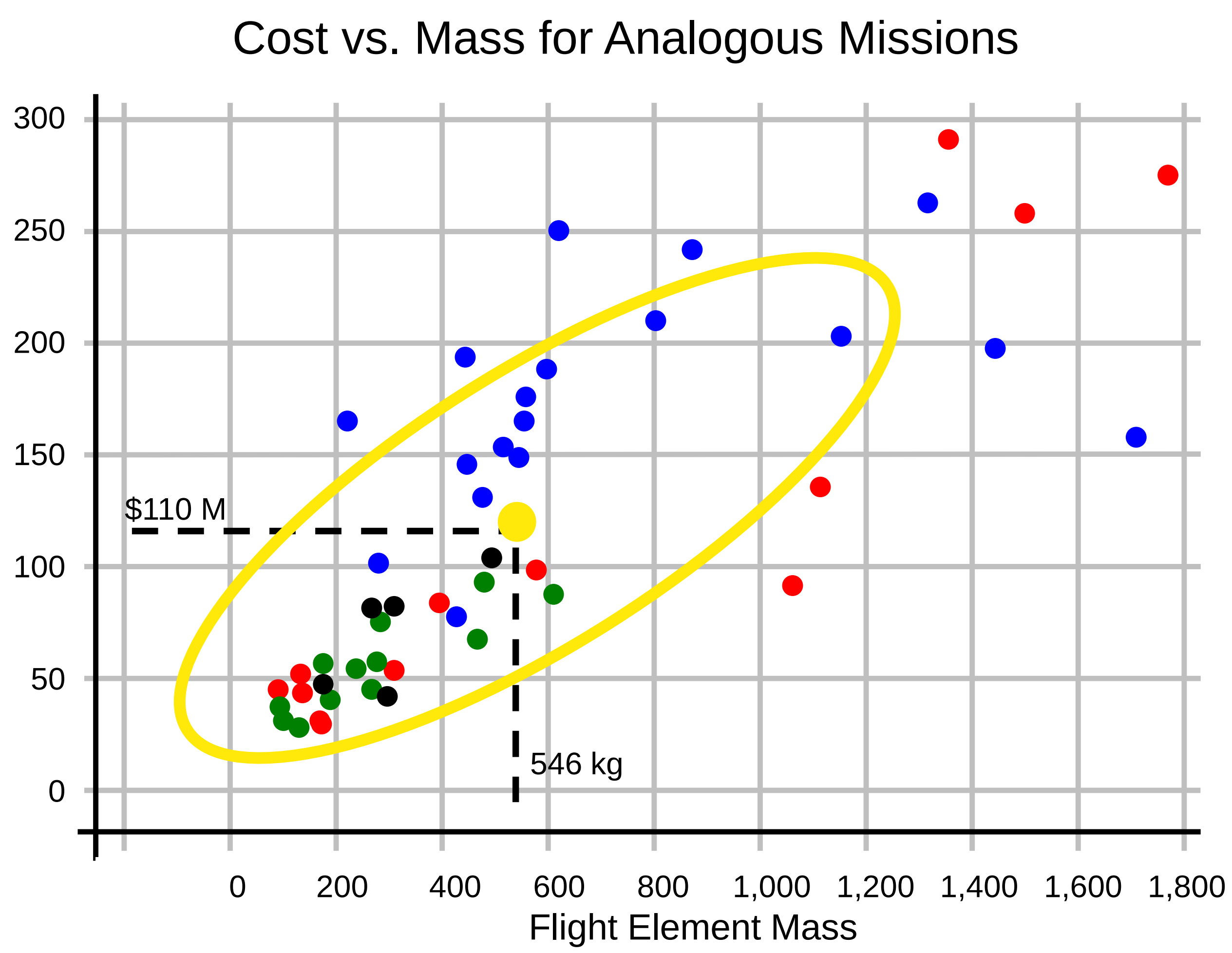
- Community perspective workshops on science priorities
- Facilitated discussions to develop focused science requirements

Science Goals	Science Objectives	Scientific Measurement Requirements: Physical Parameters	Scientific Measurement Requirements: Observables	Instrument Performance		Projected Performance	Mission Requirements
Goal 1	Objective 1	Column Density of Absorber	Absorption Line	Alt. Range	XX km	ZZ km	Observing strategies requires yaw & elevation maneuvers Launch window to meet nadir and limb overlap requirement Need NN seasons to trace evolution of phenomenon Need MM months of observation to observe variability of phenomenon
		Density and Temperature of Emitter	Emission Line				
		Size of Features	Morphological Feature	Vertical Resolution	XX km	ZZ km	
				Horizontal Resolution	XX deg. XX lat. XX long.	XX deg. XX lat. XX long.	
			Rise time of eruptive phenomena	Temperatur e Resolution	XX min.	ZZ min.	
				Precision	XX K	ZZ K	
				Accuracy	XX K	ZZ K	

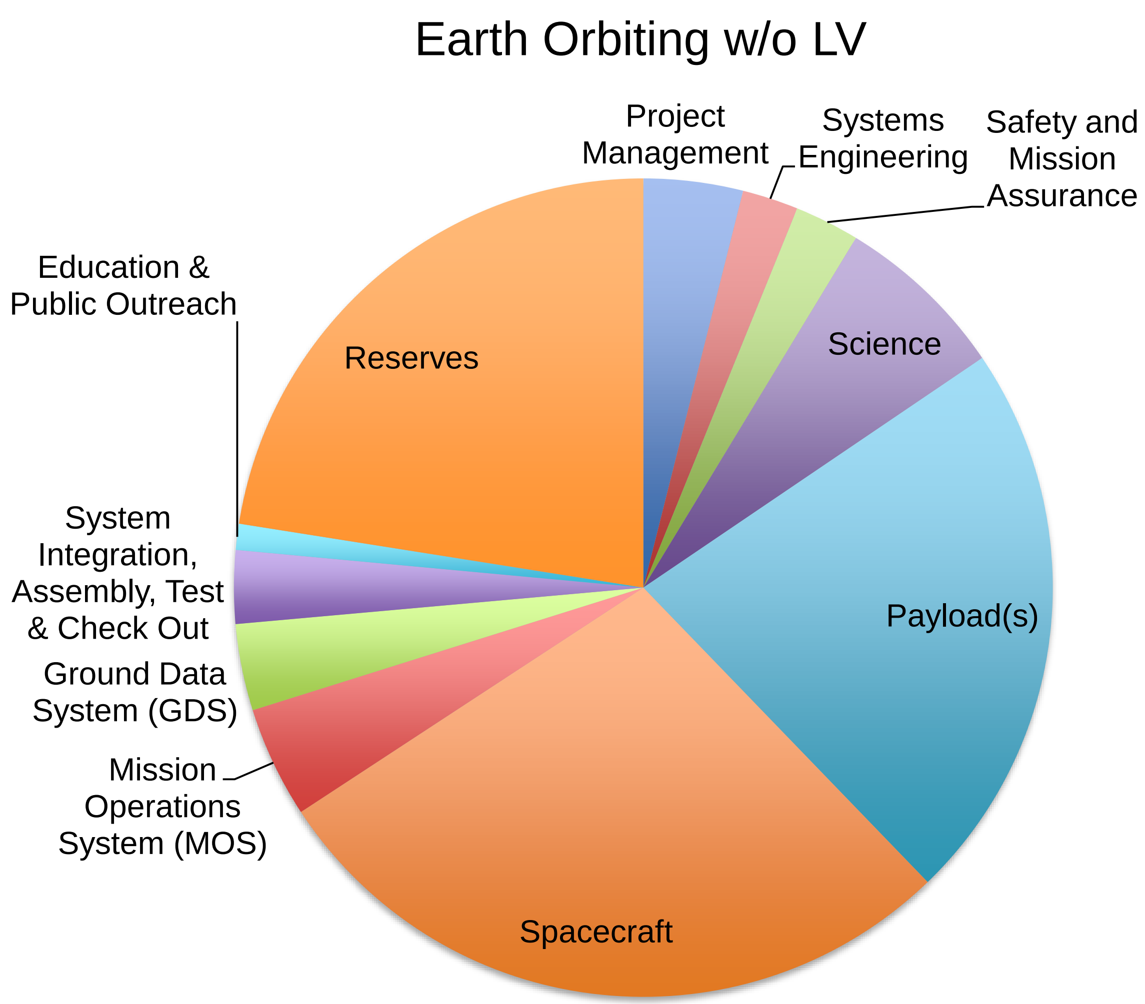
Table Example of Science Traceability Matrix from NASA AO

Cost Solutions

Analogy Mission Comparison



Rules of Thumb



The cost information contained in this document is of a budgetary and planning nature and is intended for informational purposes only. It does not constitute a commitment on the part of JPL and/or Caltech.

Stop by our poster to discuss possibilities

Poster Session IN13B: Recent Advances in Deep Learning and Data Analytics in Earth, Atmospheric, and Planetary Sciences

What? Tactical Approaches for Trading Science Objectives Against Measurements and Mission Design: Science Traceability Techniques at the Jet Propulsion Laboratory (IN13B-0072)

When? Monday, 11 December 2017, 13:40 - 18:00

Where? Poster Hall D-F

Who? Alfred Nash, JPL Team X Lead Engineer